



Petroleum Sites: What More Should We Do?

**Presented By
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(NAVFAC EXWC)**

Presentation Overview



- **Introduction/Objective**
- **Overview of 3 tools and methods**
 - **Carbon Traps**
 - **Transmissivity**
 - **API's TPH-CWG Method**
- **Review Case Studies at Navy Sites (JPHC, Fallon)**
- **Summary**

Objective



- **Discuss alternatives methods to characterize LNAPL remaining at petroleum impacted sites**
- **Provide an overview of each tool and what information each provides**
- **Discuss the how this information can be leveraged into overall site management strategies**
 - **Residual risk remaining at a site**
 - **Transition from active to passive management**
 - **Potential for RC Acceleration**

Let's Kahoot!



- How many people are running active recovery systems?
 - Yes
 - No



Has LNAPL been recovered to max extent?

Supplemental Lines of Evidence



Lines of Evidence	Data to Support Line of Evidence
No Risk to Receptors	<ul style="list-style-type: none">- HHRA and ECO Risk Assessment- Fingerprint LNAPL- Distance of plume from receptor
NSZD and natural attenuation documented	<ul style="list-style-type: none">- Carbon Trap Analysis
Areal Extent of Mobile LNAPL Footprint – Stable or Decreasing	<ul style="list-style-type: none">- Historic trend analysis in presence of FP- LNAPL footprint maps
Asymptotic Recovery	<ul style="list-style-type: none">- Historic Free Product recovery trend analysis
Remaining product has low mobility/ recoverability	<ul style="list-style-type: none">- Transmissivity Test- Fingerprint LNAPL- Viscosity test

Natural Source Zone Depletion



- **Rate of biodegradation in vadose zone**
- **Four ways to measure:**
 - **Carbon Traps**
 - **Dynamic Closed Chamber**
 - **Gradient Method**
 - **Temperature-Based Method**
- **Reported in gal/acre/year**
- **Can be on the order of 100s to 1000s of gallons per acre per year**

Let's Kahoot!



- How many people have heard of carbon traps or other CO₂ flux measuring methods?
 - Yes, never used though.
 - Yes, deployed them at one of my sites
 - No, never heard of them



CARBON TRAPS



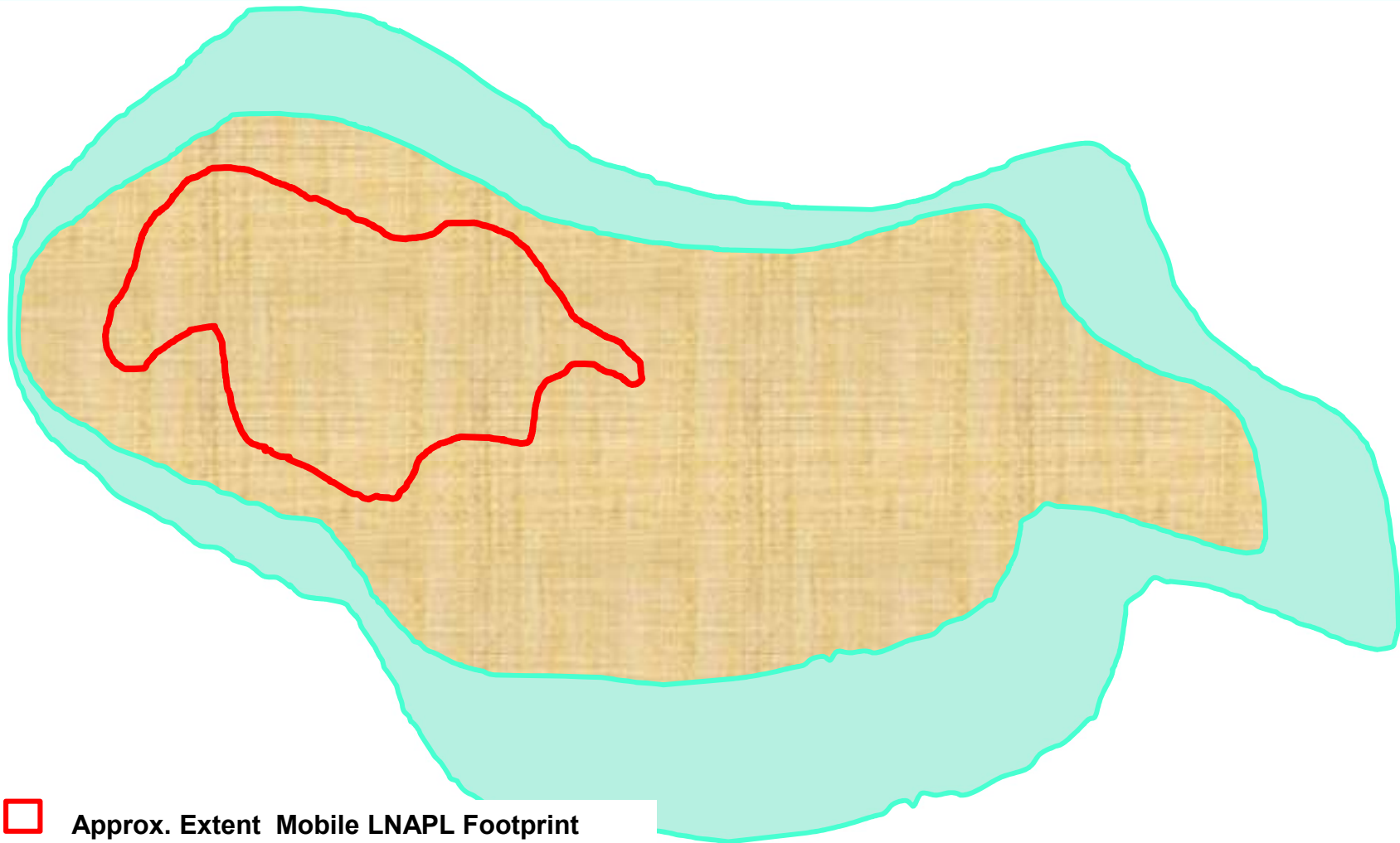
- Measures CO₂ flux from vadose zone
- Determine rates of NSZD
- Correction for background using ¹⁴C analysis
- Easy to deploy
- Typical deployment is 2 weeks
- 4" or 8" receptors available






Permanent
concrete receptor

Mobile, Residual and Dissolved Phase Plumes

How does that change overtime?



-  Approx. Extent Mobile LNAPL Footprint
-  Approx. Extent Residual / Historical LNAPL Footprint
-  Approx. Extent Dissolved Phase Plume

Let's Kahoot!



- **Have you evaluated LNAPL transmissivity at your site?**
 - **No, what's that?**
 - **Yes, conducted a bail down test**
 - **Yes, using historical recovery data**



LNAPL Transmissivity



- Volume of LNAPL through a unit of width of aquifer per unit time per unit drawdown
- Line of evidence to predict LNAPL recoverability
 - *Difficult to recover if transmissivity is $<0.1-0.8 \text{ ft}^2/\text{day}$*
- Dependent on:
 - Soil type and properties
 - e.g. porosity, conductivity
 - Chemical and physical properties of the LNAPL
 - e.g. density, viscosity, composition
 - LNAPL saturation in the formation
 - Thickness of the mobile NAPL

LNAPL Transmissivity



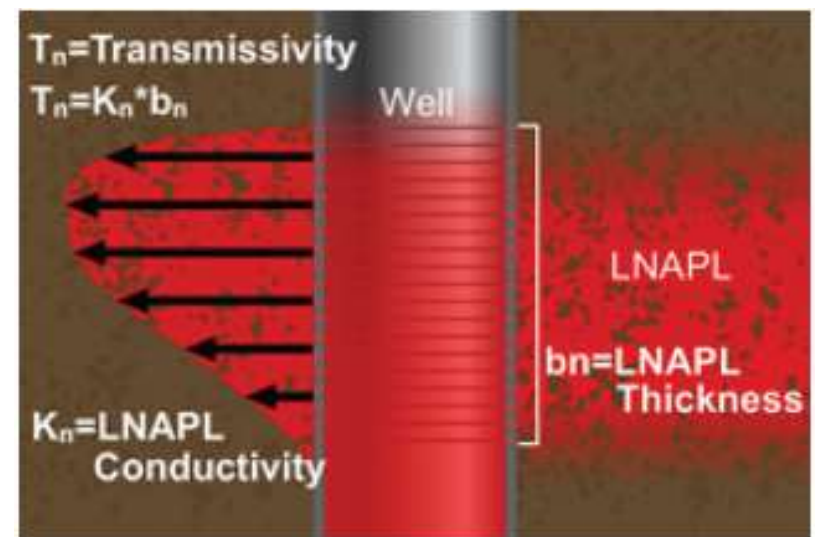
- Calculated value
- Units = $length^2/time$
- Rates determined by:
 - Conducting a bail down test
 - Using historical recovery data
 - Manual skimming method

$$T = K * b = l^2/t$$

T = transmissivity

K = conductivity

b = thickness



NAVFAC, 2015

Let's Kahoot!



- **Have you fingerprinted LNAPL and soil/GW samples?**
 - **Yes, carbon fractionation only**
 - **Yes, carbon fractionation for aliphatic and aromatic**
 - **No, never**



American Petroleum Institute's

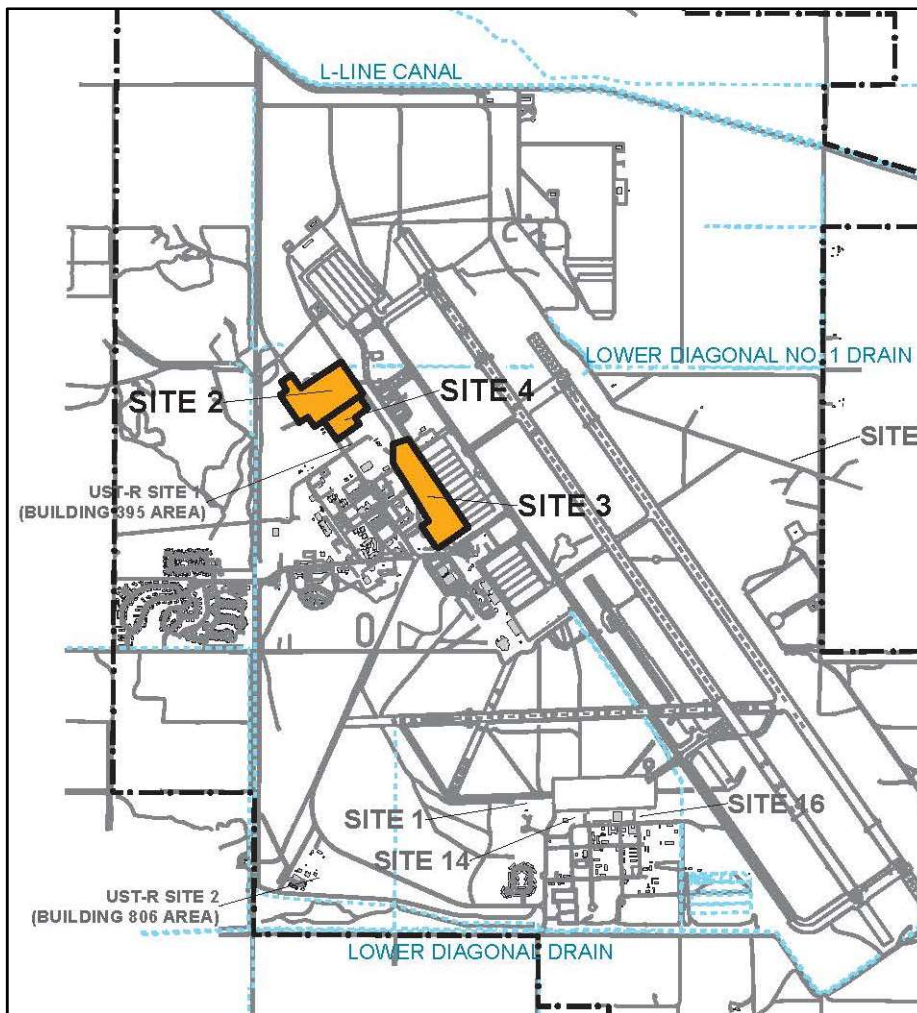
TPH-CWG Risk Based Method



- Method developed to calculate the risk associated with petroleum hydrocarbon mixtures
- Fractionation analysis distinguishes by
 - Carbon number, and
 - Compound Classes (Aliphatic vs Aromatic)
- Analysis available for:
 - Groundwater samples
 - Soil Samples
 - LNAPL Free Product samples

Case Study – NAS Fallon

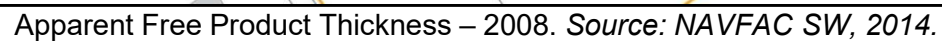
ESTCP Project ER-201582



NAS Fallon Northern Operable Unit. Source: NAVFAC SW, 2014.

Site Description

- ❖ Shallow groundwater (~8-10 ft.)
- ❖ Up to 85,000 gallons of fuel or fuel and water mixture released
- ❖ Fuel removal activities since the early 1990s
- ❖ Area of product thickness has decreased significantly since 2008



Case Study – NAS Fallon

ESTCP Project ER-201582



NAVFAC EXWC field engineer deploying the carbon traps.
NAVFAC EXWC ER-201582.

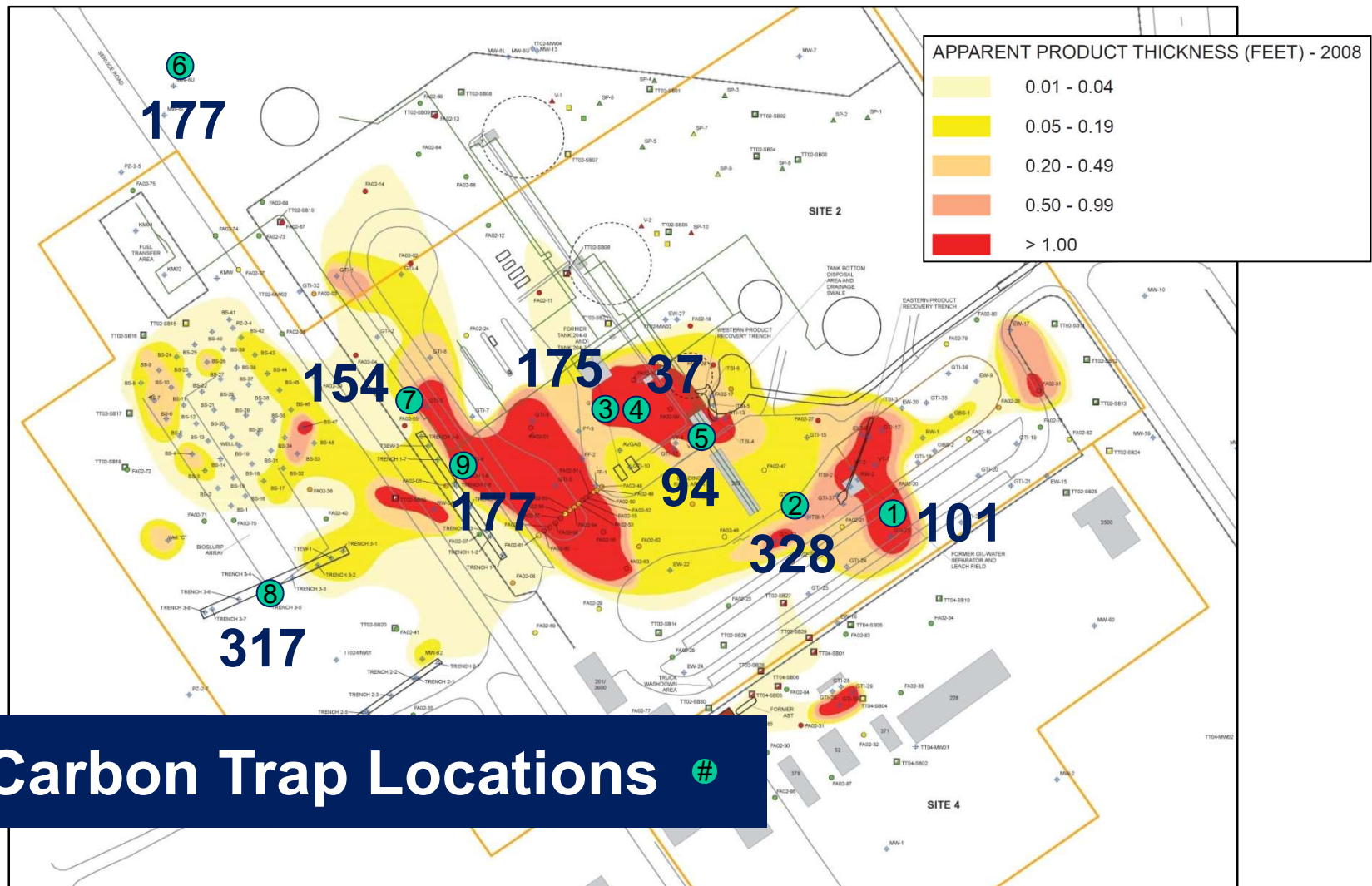


Deployed carbon trap. *NAVFAC EXWC ER-201582.*

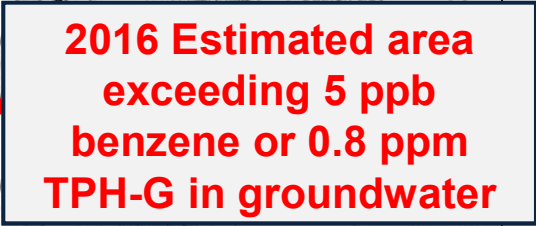
Apparent Free Product Thickness – 2008. *Source: NAVFAC SW, 2014.*

Preliminary Data

NAPL Loss Rates – gallons per acre per year

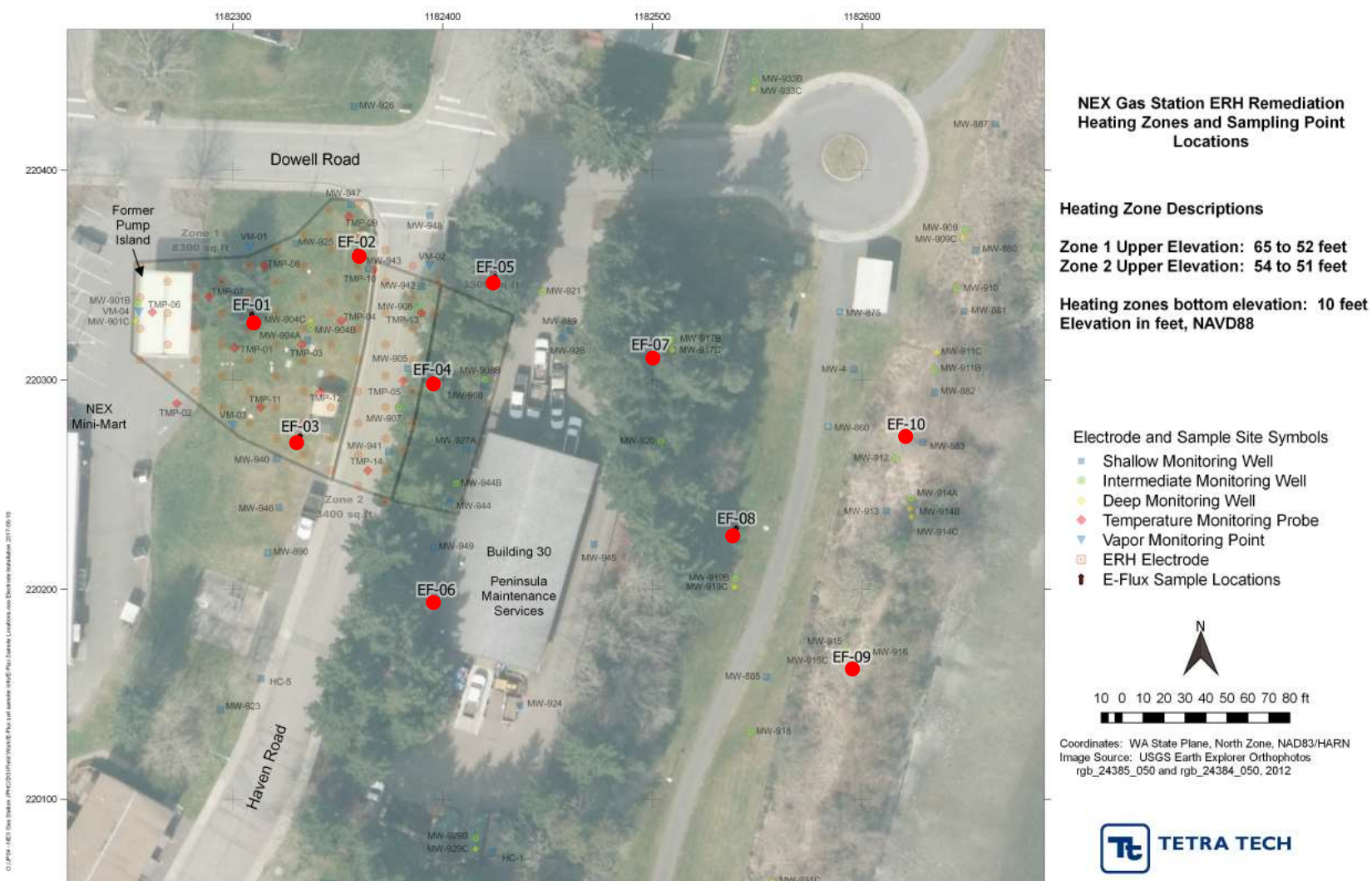


Apparent Free Product Thickness – 2008. Source: NAVFAC SW, 2014.



JPHC Case Study

Carbon Trap Locations



JPHC Case Study

Deployed Carbon Traps

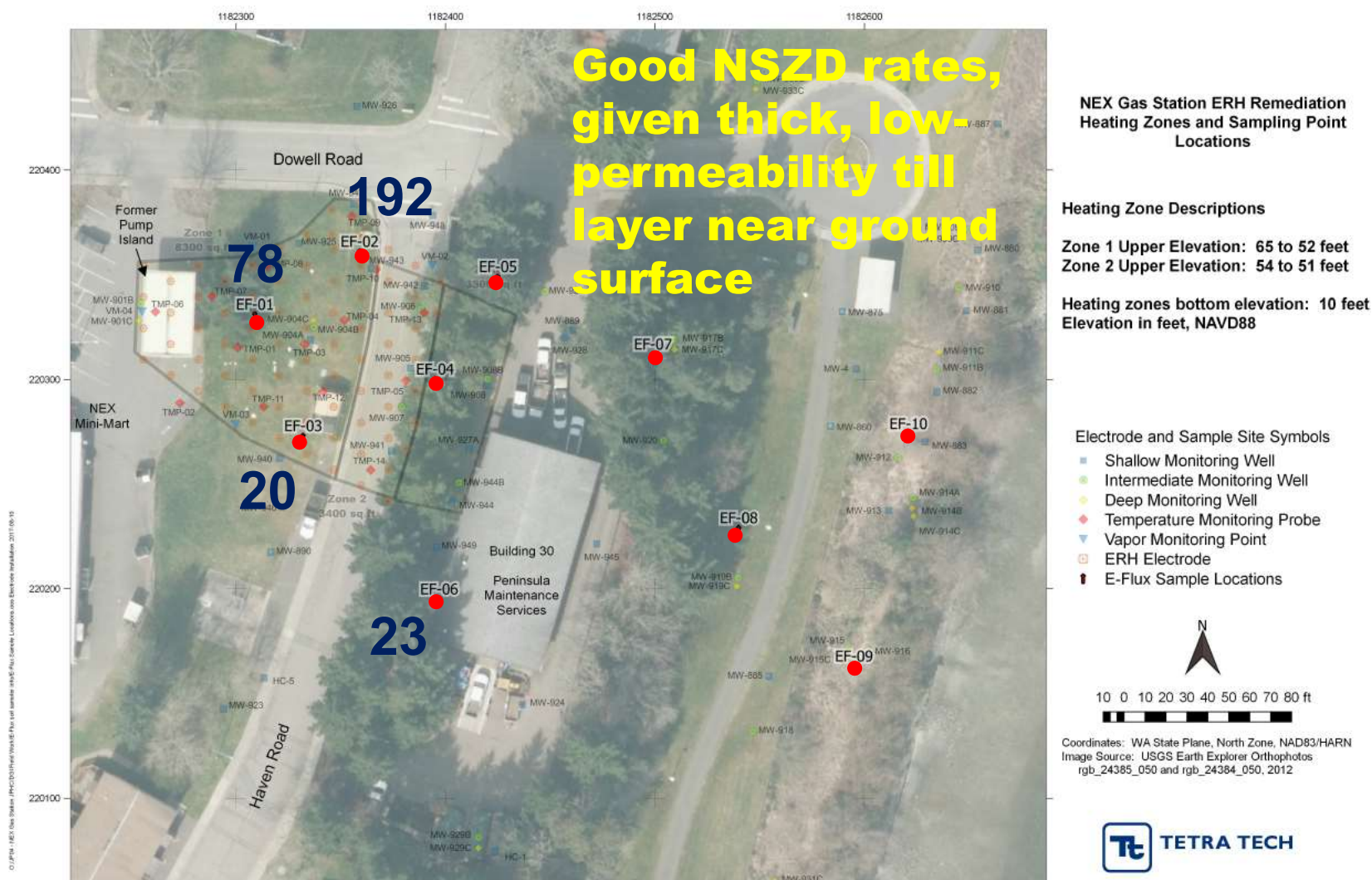


Permanent
concrete receptor



NAVFAC NW

Preliminary Data - NAPL Loss Rates – gallons per acre per year



NSZD – Other Sites



NSZD Study	Site-Wide NSZD Rate (gallons per acre per year)
Six Refinery Terminal Sites (McCoy, 2012)	2,100 – 7,700
1979 Crude Oil Spill (Sihota et al., 2011)	1,600
Refinery/Terminal Sites in Los Angeles (LA LNAPL Wkgrp, 2015)	1,100 – 1,700
Five Fuel/Diesel/Gasoline Sites (Piontek et al, 2014)	300 - 3,100
Eleven Diverse Petroleum Sites (Palaia, 2016)	300 – 5,600

New Developments in LNAPL Site Management Fact Sheet, NAVFAC 2016

Knowledge Check



- 1. T/F - Carbon traps measure total CO₂ flux and can be used to determine NSZD rates.**

- 2. Transmissivity can be calculated by:**
 - a) Conducting a bail down test**
 - b) Using historical recovery data**
 - c) Manual skimming method**
 - d) All of the above**

- 3. T/F – API's TPH-CWG Method uses bulk TPH concentrations to assess risk from residual LNAPL.**

Summary



- **Many advances in tools to help refine site CSM in order to make informed site management decisions**
- **NSZD measurements can be made using tools such as the carbon dioxide trap to estimate biodegradation rates**
- **Transmissivity tells us information regarding the recoverability of product at our sites**
- **TPH fractionation analysis can help us evaluate the risk of residual product at our sites**
- **All of these tools help support lines of evidence for Response Complete (RC) or transition to more passive recovery methods**

Contacts and Questions



Points of Contact

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Questions?

Supplemental Information



List Helpful Resources

- **New Developments in LNAPL Site Management**
https://www.navfac.navy.mil/content/dam/navfac/Specialty%20Centers/Engineering%20and%20Expeditionary%20Warfare%20Center/Environmental/Restoration/er_pdfs//navfacexwc-ev-fs-1709-newdev-lnapl-201704.pdf
- **Recent Developments in Petroleum Site Management (OER2 Webinar October 19th, 2016)**
https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/erb/oer2.html#past_topics
- **LNAPL Site Management – How to use Tools to Support Monitored Natural Attenuation and Risk Based Closure (RITS 2017 Pending)**
https://www.navfac.navy.mil/navfac_worldwide/specialty_centers/exwc/products_and_services/ev/erb/rits/pastrits.html



Backup Material

Jackson Park Housing Complex – OU1

Cross-Sectional View

